25. A GRAVITY EXERCISE SYSTEM

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INTRODUCTION

The authors' interest in the possibility of employing gravity in a more efficient manner as the basis for a muscle conditioning exercise system stems from early findings of the space program regarding exposure to weightless environment. With the elimination of gravity, the normal loading of muscles during the conduct of routine activities is removed with an attendant muscular deconditioning and deterioration of muscle bulk. With a protracted period of weightlessness, the deterioration increases to potentially create a problem of cardiovascular pooling of the blood. Even inactive individuals within earth's gravity generally do not suffer these problems, or if they do, only mildly.

In other words the natural body gravitational stresses related to relatively simple natural activities have an extremely beneficial effect upon the body's muscular system even without a specific program of exercise. Simply resisting the ever-present gravitational pull in the most basic activities, such as keeping one's equilibrium, standing or sitting, walking, etc., forms a significant part of maintaining the muscular system at a minimum acceptable level of condition and tone.

With this perspective in mind the authors sought to determine ways to maximize the benefits we already receive in so many natural ways. The objective was to extend the localized stresses obtained naturally to the full body, if possible, and to do it more efficiently. Additionally, it was hoped to evolve a more effective method of muscle conditioning than is derived from ordinary unconscious reactions to a relatively inactive daily routine.

WHAT IS GRAVITY EXERCISE?

Gravity exercise is the sum total of muscular tone and conditioning that derives from the controlled reactions of the major body of muscles to the body's own weight in a gravitational field.

Here on earth in the presence of gravity we experience (both consciously and unconsciously) a process of weight transfer that is continually taking place. This process occurs consciously when we sit down or stand up or unconsciously when we sleep. It can occur when we suddenly react to the movement of a street car or the floor boards under our feet or upon being bumped off balance in a crowd. In all of these instances one common occurrence is taking place — the

reaction of the total body weight as transferred through the structure of the body is being redistributed between the bony or skeletal structure and the various major muscle groups. The most recognizable load path, which traces the reaction of the body's weight from the head to the pressure of the foot on the floor, is that of a compressive stress acting directly through the skeletal frame. Almost everyone has experienced lower back pain from muscle reactions involved in the transfer of the body's trunk weight through the hips and down the leg structure. In order to transfer weight directly from the bone structure, it becomes necessary to selectively tension the major muscle groups of the body. The muscles are not designed for remaining in a tension condition for anything but relatively short periods of time. Hence we notice the continual shifting from one foot to the other during a lengthy period of standing — the welcome feeling of relaxing at ease versus standing at attention — the feel of the easy chair after a long walk; all of these actions decry the relative inability of the body's muscles to react to sustained loads.

Once this relatively simple property of the human body is acknowledged, it becomes clear that if weight transfer can be (accurately) regulated, then the corresponding muscular reactions will become equally regulated. Thus, the basic principle of gravity exercise is to periodically displace the human body upon reactionless rollers so that spacial equilibrium can only be maintained by the proper tension and relaxation of the body's muscles. This full body reaction constitutes an isometric exercise.

MECHANICS OF GRAVITY EXERCISE SYSTEM

The basic GES apparatus consists of a rotating platform to support a standing individual. The platform is mounted upon two-degrees-of-freedom rollers so as to obviate the formation of any lateral reactions by means of the feet. By arranging the platform to tilt away from the vertical, the body's mass can be variously unloaded from the skeletal bone structure onto the muscle structure in direct proportion to the angle of tilt. If now we introduce a rotation of the tilted platform, the full body muscular system is exposed to a condition of gravitational reaction stress throughout each 360° of rotation. This condition is depicted schematically in Figures 1(a) through 1(d). For example, at any given point of rotation, certain groups of muscles are stressed to maintain spacial equilibrium, while other groups are relaxed. As the rotation progresses, the stresses within any muscle group must correspondingly shift to succeeding muscle groups and thereby allow the previously stressed muscles to relax. The period or frequency of this cycle of stress/relaxation is exactly set by the speed that the platform is driven.

It was stated above that the combined body structural reaction maintained equilibrium against the force of gravity. It is easily recognizable that the gravity component of weight in the platform plane would cause the two-degrees-of-freedom support to translate in the down-hill direction as indicated in Figure 1 unless an equal and opposite reaction were provided. A simple analysis of the mechanics of the situation shows that, for the body supported upon 2-D rollers to apply a reaction force in the plane of the support, an equivalent force and moment must be applied by the hands and arms (and the full body) at the upper supports. Figures 1(a) through 1(d) show that the

mechanics of the body reaction as described above for each of the positions of rotation (at a finite angle of tilt) would require a different equilibrium stress condition throughout all of the muscle groups of the body. As the platform rotates, the body muscles cyclically stress and relax at the platform rotational speed. This speed can be suitably adjusted to a value known to produce optimum isometric muscle conditioning.

GRAVITY EXERCISE SYSTEM RESULTS

The process of evaluating the conditioning effects of a particular exercise routine are difficult, to say the least. One can resort to certain extremes to obtain qualitative bounds of the effects. For example, if persons of extremely limited physical capabilities can be taught to employ the routine, then the results of physical conditioning and muscle tone are usually quite dramatic.

However, a quantitative evaluation of normally active bodies is generally difficult. Such a test was conducted at Palo Alto V.A. hospital in the course of a research endeavor involving normal adult males of approximately middle age. Data were obtained by using the electromyograph (EMG) to measure the reduction of EMG mean voltage output as a gage of the reduction in motor units required to produce the same amount of work. (NOTE: This assumes that an increase in the size of muscle fibers due to a conditioning effect, and associated with an increase in contractile strength of a given motor unit, would require fewer motor units to produce a given amount of work). Results of Reference 1, representing the EMG voltages obtained from the pectoral muscles of a typical 40 year old male subject, are shown in figure 2 as illustrative of the significant and linear decrease in myoelectric output throughout a program of one 200-second exercise per day conducted at a rate of 5 days per week for a period of 12 weeks.

This work of Carlson, et al, is cited primarily as a quantitative indication of the efficiency of the Gravity Exercise System to provide muscle conditioning and toning under normal gravity conditions. The authors have had considerable experience with the dramatic physical improvements wrought with a number of physically deficient subjects ranging from a child having cerebral palsy, to a middle aged stroke victim, to routine geriatrics.

CONCLUDING REMARKS

The muscle system of the human body is an amazing adjunct to the skeletal structure; it can take all kinds of punishment and hard use during the course of a lifetime with little or no signs of wear. This is because it is designed for walking, lifting, climbing, and working in our earth's environment. In fact, it can adjust to almost any situation - except inactivity. The muscular system rapidly loses its natural tone during any protracted period of disuse; this would, of course, include the gradual effects of lack of a gravitational pull upon our bodies.

In order to maintain a healthy and natural body tone, all of the major muscles of the body will have to be reacted periodically whether under the influence of gravity or not. We believe that the Gravity Exercise System as

proven on earth is a logical candidate for weightless (zero g) environment by simply replacing the gravitationally induced body stresses with mechanically induced stresses. That is to say, we would require a subject to maintain upon center a spring-loaded two-degrees-of-freedom plate that is forced to rotate eccentrically. In our estimation, the subject's body reactions to overcome the spring tension force would provide an exercise that is quite similar to that of overcoming gravity in our present machine.

REFERENCE

1. Carlson, Karl E., M.D., Montero, Jose C., M.D., Gerontinos, Evangelo M., and Kerrins, Robert K.: The Use of Gravity in Isometric Exercise. The American Corrective Therapy Journal, vol. 25, no. 1, Jan.-Feb. 1971, pp. 19-22.

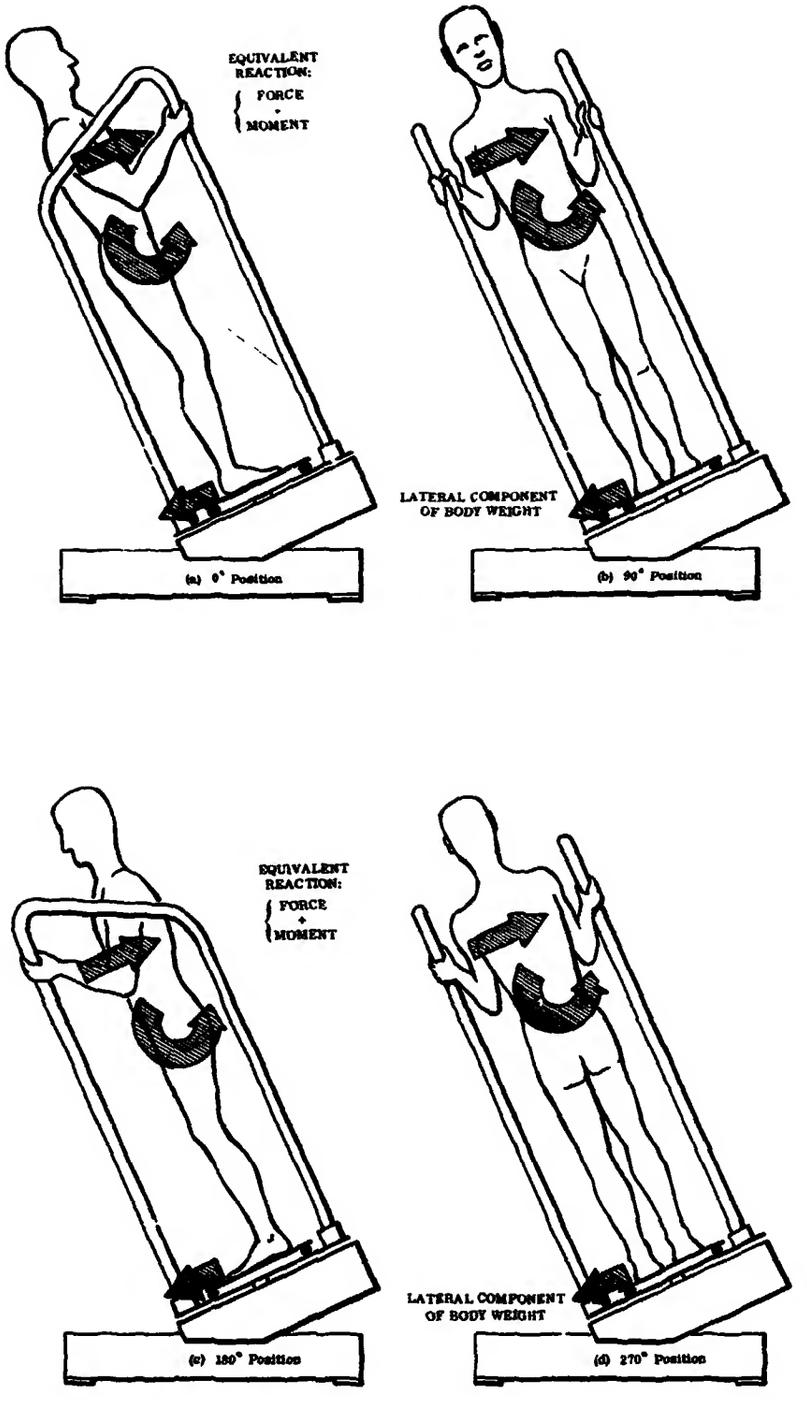

Figure 1.- Gravity exercise system.

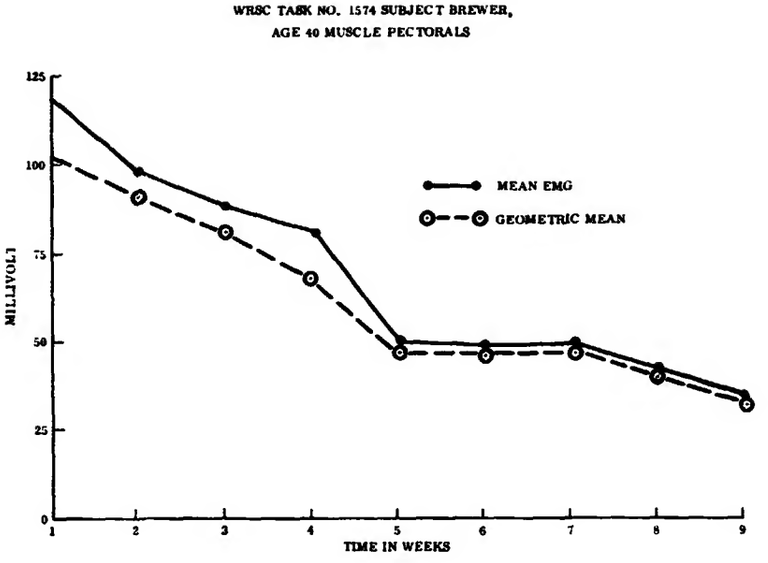

Figure 2.- Composite plot of voltage decrease against time in weeks.